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Synthesis of SiC Resin for 3D Printing of SiC Ceramics by Digital Light Processing

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ABSTRACT

Silicon carbide (SiC) resin is produced through shear mixing 0.1-1 μm SiC powders with Tethon's high load Genesis resin base. Resins of varying SiC vol.% were synthesized to test the loading limit of the resin base; 10, 20, and 30 vol.% of SiC were made with the resin base handling the higher loads quite well. Several attempts were made at printing using the Tethon Bison 1000 DLP printer with higher loads of SiC showing better results even with lower intensity UV lights and <200 seconds exposer time. Resins with lower loads showed little to no curing even with high intensity UV lights at 200 second exposer times.

BACKGROUND

Digital light processing (DLP) 3D printing is a relatively new forming technique that manufactures components by curing a resin layer-by-layer. This process has been employed for forming ceramic components as it allows for complex geometries, such as internal holes, that aren't possible through traditional techniques like injection molding or gel casting[1]. The printed pieces can then be sintered in order to remove polymers and improve the strength of the print with the cost of reducing the overall size of the print. SiC is a ceramic material that has attracted interest for DLP due to its mechanical, chemical, and thermal properties allowing for a wide range of use in many engineering fields. The goal of this project is to synthesize a 40 vol.% SiC resin for printing using the DLP 3D printing process.

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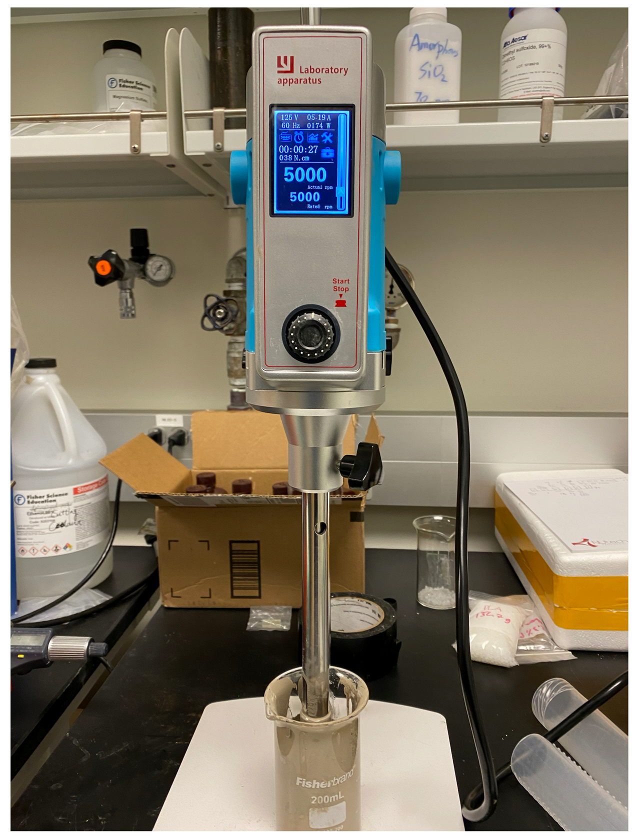
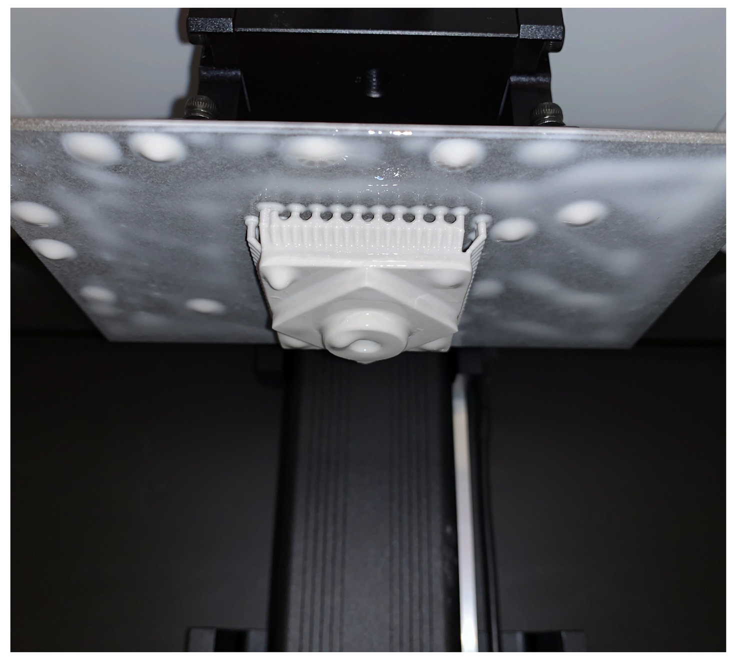
SYNTHESIS

1. Measure out the vol.% of SiC and resin base needed

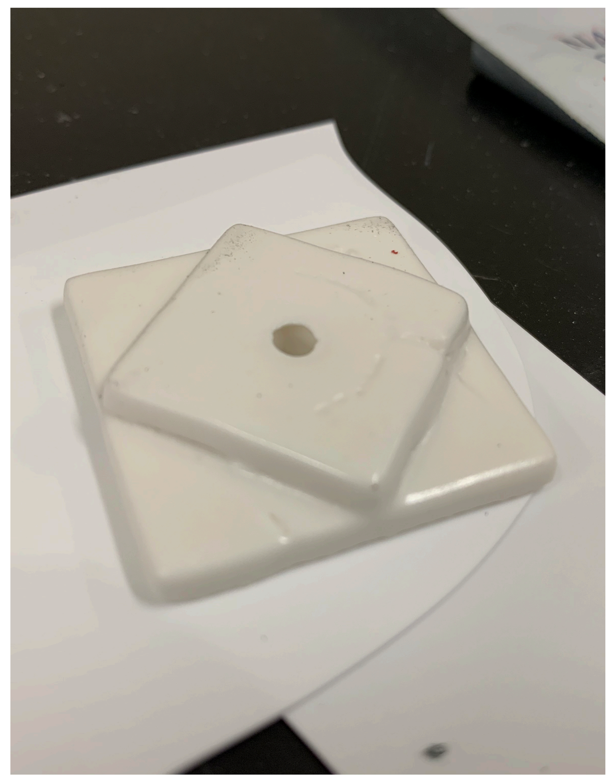
2. Incrementally add SiC powders to resin base while shear mixing



3. Continue shear mixing to maintain even dispersion



4. 3D print bulk sample piece by DLP



5. Sinter the sample to remove polymer and polish

RESULTS

Viscosity tests

Porcelite V1

Viscosity (Pa*s)	Temperature (˚C)				
Test speed (rpm)	20	30	40	50	60
6	2.537	1.518	1.338	1.218	1.078
12	2.317	1.359	1.189	1.109	0.8910
20	2.247	1.253	0.8151	0.7312	0.5094
30	2.009	1.139	0.7031	0.5992	0.4035
50	1.875	1.052	0.6114	0.4987	0.3400

Ferrolite

Viscosity (Pa*s)	Temperature (˚C)				
Test speed (rpm)	20	30	40	50	60
3	27.81	32	29.81	28.61	29.21
4	25.05	24.75	24.87	23.16	22.83
6	17.62	>20	18.52	>20	16.22

Porcelite V2

Viscosity (Pa*s)	Temperature (˚C)				
Test speed (rpm)	20	30	40	50	60
6	8.989	7.531	6.352	5.433	4.874
12	7.092	5.334	4.774	4.013	3.136

Vitrolite

Viscosity (Pa*s)	Temperature (˚C)				
Test speed (rpm)	20	30	40	50	60
6	9.189	7.591	6.412	5.074	4.894
12	6.742	5.693	4.205	3.546	2.996

30 vol.% SiC

Viscosity (Pa*s)	Temperature (˚C)				
Test speed (rpm)	20	30	40	50	60
50	0.3261	-	-	-	-

30 vol.% SiC resin has a lower viscosity than Porcelite tested under the same conditions.

The table above shows that the 30 vol.% SiC resin has a viscosity significantly lower than every other resin, even lower than the Porcelite V1 tested under the same conditions. This low viscosity could be easily observed during resin synthesis with lesser vol.% SiC loads being even more liquid. This quality indicates that the resin base used can handle even greater quantities of ceramic powder without becoming semisolid. Loads of 40 and 50 vol.% could likely be achieved without surpassing the viscosity of the Ferrolite resin. This is a good sign as higher quantities of ceramic powders within the resin leads to less shrinkage when the printed body is sintered, which would also result in less warping due to sintering. The ability for the resin base to handle more material would also allow for sintering additives that would fill the microscopic cavities that are left over after sintering for an even higher density printed body[2].

CONCLUSIONS

- ✓ SiC resins of 10, 20, and 30 vol.% with even powder dispersion were successfully synthesized.
- ✓ Higher load resins displayed more desired printing parameters.

FUTURE WORK

- ✓ Synthesize a 40 vol.% SiC resin and find the ideal printing parameters.
- ✓ Print and sinter, and polish samples from each vol.% for property testing.
- ✓ Test the ability of the resin and printer to produce complex geometries with accuracy.
- ✓ Incorporate sintering additives into the resin to improve density after sintering[2].

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2. Zhang, Jingxian, Mikio Iwasa, and Dongliang Jiang. "Dispersion of SiC in aqueous media with Al2O3 and Y2O3 as sintering additives." *Journal of the American Ceramic Society*88.4 (2005): 1013-1016.